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LOADING OF HIP MEASURED BY HIP CONTACT FORCES AT DIFFERENT SPEEDS OF WALKING AND RUNNING.

Georgios Giarmatzis* [1], Ilse Jonkers[2], Mariska Wesseling[2], Sam Van Rossom[2], Sabine Verschueren[1]
[1]Musculoskeletal Rehabilitation, [2]Human movement biomechanics, KU Leuven, Leuven, Belgium

Preferred Presentation: Oral Presentation
If your abstract is not accepted as an oral do you wish to be considered for a poster?: Yes
Clinical Biomechanics Award: No
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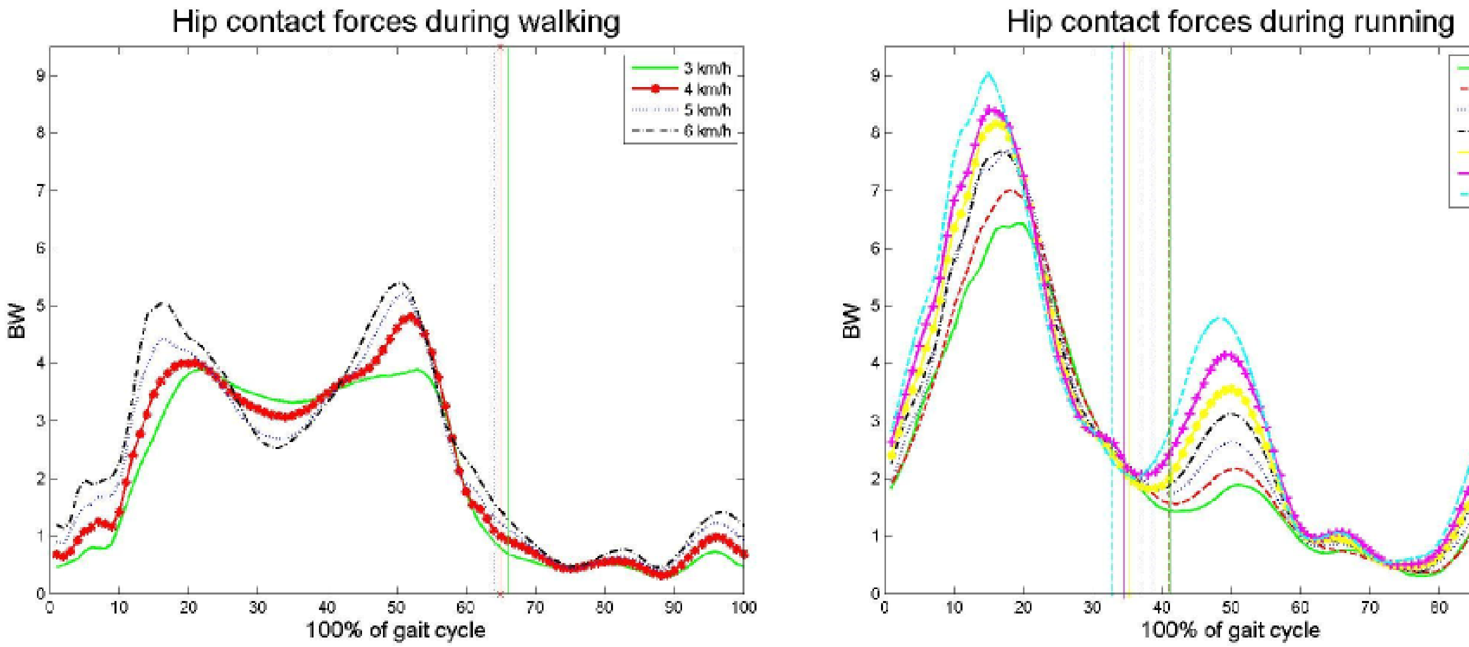
Emerging Scientific Award sponsored by Professor J De Luca: No
Promising Scientist Award sponsored by Motion Analysis: No

Introduction and Objectives: Exercise plays a pivotal role in maximizing peak bone mass in adulthood and maintaining it with aging, by imposing mechanical loading on the bone that can trigger bone mineralisation and growth [1]. Hip fractures are the most devastating and linked to highest morbidity rates when compared to the rest of the osteoporotic related fractures together [2]. Still, the optimal type and intensity of exercise that best enhances hip bone strength remains poorly characterized, partly because the exact loading of the hip produced by the diverse types of exercises is not known. Thus, the goal of this study was to quantify peak hip loading during walking and running at different speeds and acquire a better insight into the biomechanics of the motion in question.

Methods: 20 young healthy adults walked and run on a split-bet treadmill, in a speed range of 3 – 12 km/h, with an increment of 1 km/h. By means of integrated motion capture as an input to musculoskeletal modeling in Opensim, kinematics, kinetics and hip contact forces (HCFs) were calculated. Muscle forces were obtained by solving the static optimization algorithm. The cost function was set to minimize the squared sum of all muscle activations.

Results: Ensemble curves of HCFs during walking and running are shown in Figure 1. During walking, HCFs have a two peak profile whereby the first peak (Peak1_HCF) during heel strike increases from 4.03 BW to 5.26 BW and the second (Peak2_HCF) during toe-off from 4.1 BW to 5.4 BW, by increasing speed from 3 to 6 km/h (Table 1). During running, there is only one peak HCF (Peak_HCF) during mid-stance that increases from 7.11 BW to 9.48 BW, by increasing speed from 6 to 12 km/h (Table 1). Speed related profiles of peak HCFs and ground reaction forces (GRFs) reveal a different progression of the peaks. Larger percentage increase from 3 to 6 km/h was identified for peak HCF when compared to peak GRFs during walking and running. Larger variability of peak HCFs was calculated during walking (~ 13 – 24.5%) and running (~ 16 – 20%) than in peak GRFs (~ 3 – 8% during walking and ~ 8 – 10% during running). Regression analysis of peak HCFs and coinciding hip moments for each speed showed that hip adduction moment best predicts Peak1_HCF (mean R^2 = 0.6) during walking and Peak_HCF (mean R^2 = 0.7) during running, whereas hip extension best predicts the Peak2_HCF during walking (mean R^2 = 0.58).

Figure:



Caption: Figure 1

Conclusion: Based on our analysis, peak HCFs increase significantly with increasing speed during walking and running. Further analysis showed that speed has a stronger impact of speed on peak HCFs than on peak GRFs. Discrepancies in variability and speed progression of peak HCFs and GRFs question the notion of peak GRF as predictor of peak skeletal loading. As a consequence, clinically relevant outcomes were also investigated as possible predictors of peak HCFs. Results from regression analysis of peak HCFs and hip moments indicate the major influence of muscle activity on peak HCFs, since muscles exhibit high force output to equilibrate external moments. The present study contributes hereby to a better understanding of musculoskeletal loading during walking and running in a wide range of speeds, offering valuable information to clinicians and scientists exploring bone loading as a possible non-pharmacological osteogenic stimulus. Through modeling, a deeper insight into joint forces was established, illustrating that ground reaction forces and external moments can only partially describe the true musculoskeletal bone loading and that muscle action used to balance external joint moments is the most important factor in affecting bone loading during different exercises. In future research these results can be utilized in more elaborate techniques, such as finite element analysis, in order to fully understand the mechanisms underlying bone reaction to load.

Table:

	Walking								**Running**						
Velocity	**3 km/h**		**4 km/h**		**5 km/h**		**6 km/h**		**6 km/h**	**7 km/h**	**8 km/h**	**9 km/h**	**10 km/h**	**11 km/h**	**12 km/h**
	Peak1	**Peak2**	**Peak1**	**Peak2**	**Peak1**	**Peak2**	**Peak1**	**Peak2**							
Peak GRF (BW)	1.06 (0.03)	1.06 (0.04)	1.1 (0.04)	1.09 (0.06)	1.17 (0.06)	1.12 (0.09)	1.24 (0.1)	1.14 (0.08)	2.03 (0.22)	2.07 (0.22)	2.21 (0.21)	2.28 (0.19)	2.35 (0.2)	2.37 (0.25)	2.45 (0.22)
Peak HCF (BW)	4.03 (0.7)	4.1 (0.9)	4.15 (0.72)	4.8 (0.87)	4.58 (0.85) [4]	5.17 (0.82) [4]	8.02 (1.44)	5.4 (0.82)	7.11 (1.3)	7.3 (1.44)	8.02 (1.44)	8.61 (1.58)	8.41 (1.34)	9 (1.6)	9.48 (1.53)

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[2] S. Boonen et al. *Best practice & research. Clinical endocrinology & metabolism*, vol. 22, no. 5, pp. 765–85, Oct. 2008.

Disclosure of Interest: None Declared